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Published in:
Journal of money credit and banking

DOI:
10.1353/mcb.2002.0030

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The Option to Wait to Invest and Equilibrium Credit Rationing

Stiglitz and Weiss (1981) show that firms considering risky projects have higher reservation interest rates and hence it is optimal for a bank to reduce loan supply. In this note we show that when the risk involved in an investment will be resolved in the future, investors with riskier projects have a greater return from waiting. More risky projects have lower reservation interest rates and hence there is no motive for banks to ration credit demand.

STIGLITZ AND WEISS (1981) show that asymmetric information may lead to a situation where, among observationally identical loan applicants, some get a loan whereas others are denied credit. The key to this result is the assumption that the payoff for the investor is an increasing function of the riskiness of the investor's project. High-risk investors are willing to pay a higher lending rate for a loan. This implies that the cutoff lending rate above which a firm decides not to invest, the so-called *reservation rate*, is the lowest for the least risky loan applicant. Banks know the expected return of the project, but cannot distinguish between *bad* (low-risk) and *good* (high-risk) firms. An increase in the lending rate has two opposite effects on bank returns. On one hand, it increases the average rate of return for banks because banks earn more interest on the loan. On the other hand, it causes loan applicants with the lowest risk to drop out of the loan market. Above a certain threshold lending rate the negative effect will dominate, so the optimal policy for the bank is to ration credit and not to raise the lending rate. The message is that equilibrium rationing is a rational choice.

In the Stiglitz-Weiss (SW) model the choice given to the firm is to invest or not to invest given that investment is irreversible. However, there is no possibility for the firm to wait. The literature (see, for example, McDonald and Siegel 1986) shows that there might be a positive option value of waiting (or early abandonment). In this note we show that in a simple reformulation of the Stiglitz-Weiss model for a world where uncertainty will be resolved in the future and the investor has the possibility to wait, credit rationing does not occur. The results of this paper illustrate that when the

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Journal of Money, Credit, and Banking, Vol. 34, No. 1 (February 2002)

decision is whether to invest before it is known whether a project will be successful or after, the investors with riskier projects have a greater return from waiting. Since the return for delay is highest for the borrowers with the riskier projects, they are the last to invest immediately as the interest rate rises. This implies that an increase in the lending rate by banks drives the *bad* firms out of the loan market and not the *good* firms as is the case in the Stiglitz-Weiss model. This result reduces the empirical relevance of credit rationing in the sense of Stiglitz-Weiss.

1. STYLIZED VERSION OF THE STIGLITZ-WEISS MODEL

We start by summarizing the main elements of the SW model in the context of the model we use hereafter. The model includes two types of agents: one commercial bank and different types of risk-neutral loan-applying firms. Each firm holds an investment opportunity. In contrast to the original SW model we assume a rudimentary multi-period setting. In fact, we have an infinite number of periods but the basic choice problem is concentrated on two periods. The state of the world in the first period ($t=0$) is known and before the information is revealed projects cannot fail (so there is no advantage for riskier projects in the first period). In the second period ($t=1$) and thereafter (to infinity) there is a good and a bad state. We suppose that once a certain state is reached in the second period, this state will continue to infinity. The decision on the size of the capital stock is made in the first period: for the sake of simplicity we assume investment I to be equal to the size of the capital stock K. Firms have an amount of initial wealth W, which we assume to be smaller than the amount needed to invest (I). Hence, the (investing) firm demands a loan $L=I-W$. The bank supplies loans at a rate r.[1] If a firm invests, the payoff in the first period is equal to P_0, which we assume to be smaller than the initial investment I. Empirical observations on the expected lifetime of capital goods illustrate that it is plausible to assume that the first-period payoff is likely to be less than the amount invested (see, for example, Jorgenson 1996, p. 46). In the good state the return in the second period is R_i, where i indicates the firm type. In the bad state the return is assumed to be zero (but this assumption can be relaxed straightforwardly). In line with Stiglitz and Weiss, we assume that the expected return of all projects is equal. The firms differ with respect to the return when the project is successful (R_i) and the probability of success (q_i). A decrease in q_i means greater risk in the sense of a mean-preserving spread (see Rothschild and Stiglitz 1976). Banks know that projects differ in riskiness, but they are unable to observe which projects are risky and which are not. The assumption of equal returns for all projects i implies

$$P_0 + q_i \sum_{t=1}^{\infty} \frac{R_i}{(1+r)^t} = P_0 + \frac{q_i R_i}{r} = A \tag{1}$$

1. For ease of exposition we assume that the loan rate r is also used to discount future cash flows.

for all i, where A is the expected present value of all projects. Rewriting gives $R_i = r(A - P_0)/q_i$, again for all i. It can now easily be seen that in this arbitrage-free world the risky project has higher returns if it is successful.

For a positive net present value ($NPV_{i,t=0}$) a firm will decide to invest. It is important to note that the returns R_i are assumed to be independent of the initial investment, since this amount is the same for all firms. The net present value for firm i ($NPV_{i,t=0}$) equals [using equation (1) and $I = W + L$]:

$$NPV_{i,t=0} = -I + L + P_0 - rL + (R_i - rL)q_i \sum_{t=1}^{\infty} \frac{1}{(1+r)^t} = -W - L(r+q_i) + A . \quad (2)$$

The reservation interest rate is the interest rate above which the firm decides not to invest. Hence, the reservation rate is obtained by setting the $NPV_{i,t=0}$ equal to zero:

$$r_i = \frac{A - W}{L} - q_i . \quad (3)$$

From equation (3) it can be seen that the firm with the highest q_i, that is, the low-risk projects, has the lowest reservation rate ($dr/dq_i = -1$). This is basically the Stiglitz-Weiss result. If banks increase the lending rate, the lending rate may surpass the reservation rate of the good borrowers and hence the pool of loan applicants becomes worse. The natural thing for a bank to do is to reduce loan supply.

2. THE RESERVATION INTEREST RATE WHEN FIRMS HAVE THE OPTION TO WAIT

In the former section, investment is modeled as a decision to be taken now or never, assuming irreversibility and nonexpandability (see Abel et al. 1996). However, the theory of investment under uncertainty emphasizes that it might be profitable to wait to invest in order to obtain more information on the state of the world relevant to the project. The sign of the investment uncertainty relationship depends on a large number of phenomena, such as the degree of competition and returns to scale (Caballero 1991), production factor substitutability (Hartman 1976), time to build (Bar-Ilan and Strange 1996), etc. If one does not assume constant marginal productivity of capital through time (for instance, due to variable returns to scale or market power), the higher the reverting costs are the larger the probability of a negative impact of uncertainty on investment will be.

The theory of investment under uncertainty treats a real investment decision like exercising a financial call option. The equivalence between a decision to exercise a call option and a real investment decision may be clear. An investor, having the opportunity to invest and being uncertain about future variables affecting the probability of a project, may decide to wait for more information and hence may decide to delay her investment (McDonald and Siegel 1986). Real option theory implies that the standard net present value rule for investment, as used in the former section, has to be amended by taking into account that once the investment has been made, the option to invest does not longer exist. Somewhat loosely stated: investors need to be compensated for the loss in value related to the disappearance of the investment opportunity when the investment has been exercised. On the other hand, postponing the decision has benefits (more information on the state of the world), but also foregone receipts from sales.

The option value is calculated by subtracting the $NPV_{i,t=0}$ as calculated in the former section from the $NPV_{i,t=1}$, which denotes the NPV discounted back to $t=0$, when firm i waits until $t=1$. For this $NPV_{i,t=1}$ we assume that the investment is only undertaken for positive profit cases. Entrepreneurs can costlessly learn whether their project will succeed or fail by delaying one period. We assume that all information is revealed in the second period. Moreover, a potential borrower will not exit the market in response to an interest rate increase, but will just delay the investment decision. For sake of simplicity, we also refrain from entry of new projects. The $NPV_{i,t=1}$ for firm i equals

$$NPV_{i,t=1} = \frac{q_i}{1+r}\left(-W + \frac{1+r}{r}R_i\right) - q_i L = A - \frac{q_i}{1+r}W - P_0 - q_i L\,. \qquad (4)$$

The value of the option to wait (V_i) is the difference between $NPV_{i,t=1}$ and $NPV_{i,t=0}$, hence:

$$V_i = \left(1 - \frac{q_i}{1+r}\right)W - P_0 + rL\,. \qquad (5)$$

If the option value is positive, the firm will wait to invest and not demand the loan. V_i is increasing in the interest rate r, since the first-period revenue P_0 is independent of r, while short-run costs (borrowing and opportunity costs) are increasing in r. Moreover, V_i is decreasing in q_i. As can be seen from the option value, a high first-period return P_0 will increase the probability that a firm invests immediately. Even a high-risk project (low q_i) will be undertaken in the first period for a high and certain first-period return. We therefore limit the first-period return to a maximum less than the initial investment: $P_0 < I$. It is again possible to calculate the reservation rate for a firm above which it decides not to invest by setting the option value equal to zero, hence:

$$-\frac{q_i}{1+r} - \frac{P_0 - rL - W}{W} = 0\,. \qquad (6)$$

The second term represents the relative net return in the first period before uncertainty is resolved and the first term adds the effect of waiting. The effect of a decrease in riskiness of the project on the reservation rate can be obtained by implicit differentiation with respect to r and q_i. We multiply equation (6) by $(1+r)$ and differentiate the equation implicitly: $(W-P_0+(2r+1)L)dr-Wdq_i=0$. Again using $I=W+L$, this results in

$$\frac{dr}{dq_i}=\frac{W}{I-P_0+2rL}. \tag{7}$$

The sign of the effect of an increase in q_i on r is strictly positive for $P_0<I$. So projects with a low first-period return will experience an increase in the reservation rate for lesser risk. This shows that for less-risky projects (with a high q_i) the reservation rate is *higher* than for the risky projects. It implies that in our model, where firms have no costs of learning whether the project will succeed or fail by delaying one period, banks do not have to fear that an increase in the lending rate in the case of an excess demand for loans will drive out the good projects. Quite to the contrary, an interest rate increase will induce borrowers who would have undertaken the riskiest projects to delay investment.

3. CONCLUSION

In this note we show that more risky investors have a greater return from waiting when waiting reveals information about the project type. Therefore, an increase in the borrowing rate will induce risky investors to delay investment. This is in contrast to the result of Stiglitz-Weiss (1981), where banks decide to ration credit since riskier projects have higher reservation rates.

LITERATURE CITED

Abel, Andrew B., Avinash K. Dixit, Janice C. Eberly, and Robert S. Pindyck. "Options, the Value of Capital, and Investment." *Quarterly Journal of Economics* 111 (1996), 753–77.

Bar-Ilan, Avner, and William C. Strange. "Investment Lags." *American Economic Review* 86 (1996), 610–22.

Caballero, Ricardo J. "On the Sign of the Investment-Uncertainty Relationship." *American Economic Review* 81 (1991), 279–88.

Hartman, Richard. "Factor Demand with Output Price Uncertainty." *American Economic Review* 66 (1976), 675–81.

Jorgenson, Dale W. *Investment,* Part 2: *Tax Policy and the Cost of Capital*, MIT Press, 1996.

McDonald, Robert, and Daniel Siegel. "The Value of Waiting to Invest." *Quarterly Journal of Economics* 101 (1986), 707–28.

Rothschild, Michael, and Joseph E. Stiglitz. "Equilibrium in Competitive Insurance Markets." *Quarterly Journal of Economics* 91 (1976), 707–28.

Stiglitz, Joseph E., and Andrew Weiss. "Credit Rationing in Markets with Imperfect Information." *American Economic Review* 71 (1981), 393–410.